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The Wheat Stem Rust Epidemic of Kansas in 1940

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The Plant Disease Reporter is issued as a service to plant pathologists throughout the United States. It contains reports, summaries, observations, and comments submitted voluntarily by qualified observers. These reports often are in the form of suggestions, queries, and opinions, frequently purely tentative, offered for consideration or discussion rather than as matters of established fact. In accepting and publishing this material the Division of Mycology and Disease Survey serves merely as an informational clearing house. It does not assume responsibility for the subject matter.

THE WHEAT STEM RUST EPIDEMIC OF KANSAS IN 1940 1/

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Loss from stem rust of wheat, *Puccinia graminis tritici* Pers., in Kansas the past 6 years has been a matter of concern to those connected with the hard winter wheat industry of the Plains area. There is no other 6-year period in the history of wheat production in Kansas in which 4 stem-rust epiphytotics are recorded. The total loss from stem rust during these 6 years (1935-1940) is as large or larger than the combined loss which had occurred in Kansas up to that time, since the epiphytotic of 1904.

The loss from stem rust has stimulated research on the stem-rust problems affecting wheat and oats in Kansas and added attention is being directed to the matter of breeding for resistance to stem and leaf rusts of hard winter wheats and spring oats adapted to this area. Although the present breeding program, emphasizing stem-rust resistance, has been under way only about 5 years, substantial progress has been made in obtaining certain hybrids combining stem-rust resistance with resistance to other diseases and insects. In order to obtain such characters as quality, yield, winter hardiness, insect resistance, and other essential qualities, cooperative experiments with the Departments of Entomology and Agronomy have been conducted. It has been recognized by plant breeders in the Great Plains area, the hard winter wheat region, that cognizance must be taken of the fact that stem rust is a hazard to wheat production and must be considered in the future; that a variety, no matter how excellent it may be in other respects, will never be what it should be unless it has resistance to stem rust as well as to certain other diseases.

Loss of major importance from stem rust of wheat occurred in Kansas in 1935, 1937, 1938, and 1940, and for each of the first 3 of these a published report on the pertinent facts as related to the epiphytology of stem rust has been recorded 3/. The 1940 record is given in the present report. When leaf rust, *Puccinia triticina* Eriks. [*P. rubigo-vera tritici* (Eriks. & Henn.) Carl.], was a factor during any of these years, recognition of this fact was made, as well as of any other disease or condition that was of importance in evaluating the loss from stem rust.

1/ Contribution No. 418 from the Department of Botany.

2/ The author gratefully acknowledges the help of John O. Miller, Extension Specialist in Plant Pathology, Kansas State College, who accompanied him on the field trip in which wheat fields were examined.

3/ Johnston, C.O., et al. The stem rust epidemic of 1935 in Kansas. Plant Disease Reporter Supplement 92, 1936.

Johnston, C.O., L.E. Melchers, and J.O.Miller. The wheat stem rust epidemic of 1937 in Kansas. Plant Disease Reporter Supplement 107. 1938.

Melchers, L.E., and C.O.Johnston. The wheat stem and leaf rust epidemics of 1938 in Kansas. Plant Disease Reporter Supplement 116. 1939.

Crop Conditions Leading Up to the Stem-rust Epidemic of 1940

In 1940 Kansas was still struggling with the prolonged drouth conditions that have prevailed in the State for the past 9 years. It was the lack of moisture in the fall of 1939 that set the stage for much of the trouble that was to follow in the spring of 1940 when stem rust appeared.

In June 1939, heavy rains fell and it appeared as if the row crops were off to a good start. The latter part of July, however, was dry, and hot weather and drying winds began to show their effect on corn and sorghums. Although heavy rains fell the first half of August, high temperatures, scorching winds, and lack of rain during the last of August, quickly dissipated what moisture remained. These same conditions were making it impossible to prepare land for a satisfactory seedbed for the 1940 wheat crop. Dry, hot weather prevailed in September over the entire State. No relief from the drouth occurred in October, November, and part of December. The soil was dry for several feet below the surface. The entire fall of 1939 was one of the warmest and driest in the records of the Weather Bureau in Kansas. Trees, shrubbery, pastures and alfalfa were severely damaged. The vast areas of wheat lands that had been disked or plowed were dry. A very small wheat acreage was planted on land that had enough moisture to give the crop a start, but each succeeding week saw the wheat deteriorating. In desperation thousands of acres were sown in late November and December in soil that was bone dry. A rain about the middle of November helped some of the wheat that had started to grow and aided some of the seed in other fields to germinate. Rains were not heavy, nor were they distributed over a wide enough area in the wheat belt to be of much benefit. This was especially true of the western quarter of the State. Towards the end of December snows fell in western Kansas to a depth of 1 to 6 inches and this, no doubt, gave some of the wheat a start, but they came too late, as will be shown later. Some farmers drilled wheat after the snow had fallen. Traveling in central and western Kansas in November and December, one was struck by the absence of anything green -- the fields were bare of growth. By the middle of December crop conditions were estimated as 35 percent of normal for wheat, probably the poorest prospect for that time of year in the history of the State. Temperatures remained abnormally high for that time of year, the lowest temperature at Manhattan up to December 24 being 16° F.

Following this, severe winter weather with some subzero temperatures occurred in January, the lowest being -11° on January 17. Farmers were still attempting to sow their wheat, whenever there was a break in the cold spell, although warnings had been given by the Agricultural Experiment Station that such a practice was futile.

Some improvement was observed in the wheat in April, but the crop estimate on April 1 was 59,400,000 bushels, the lowest in Kansas since 1917. Eastern Kansas wheat fields were fair to good. Conditions west of a line running north and south of Salina were poor. Much of the wheat in this area did not emerge until March and therefore could have little prospect of maturing. April rainfall, however, for Kansas was normal, and May and June had normal or almost normal rainfall; parts of May were unusually cool, all of which favored a very late wheat crop. In May the crop was estimated at 72,000,000 bushels [4], and much of the late wheat had made what appeared, to many, a promising start and the prospects of a good crop.

During the last week in May a trip was made through southern Kansas by College officials, who reported that thousands of acres of wheat were from 2 to 3 weeks late. These fields and a large acreage in the western part of the State that were not so far along, were faced with 2 dangerous possibilities. If the weather were to remain cool with sufficient moisture to allow the wheat to make a crop, stem rust would no doubt destroy the wheat, and if abundant moisture did not fall and seasonable temperatures prevailed, this late crop would "burn up." As will be shown, stem rust caused excessive damage, not only to this large acreage of late wheat, but also to the balance of the crop in south-central Kansas, which was a week to 10 days late.

Climatic Conditions in Kansas as Affecting Stem-rust Development in 1940

An examination of figure 1 will show the daily precipitation and maximum and minimum temperatures for the period April 1 to July 30. During most of April and up to May 3, temperatures were too low for infection and spread of stem rust. This graph indicates that moisture was favorable for stem rust development throughout this period up to perhaps the middle of July, although the distribution of rainfall for the June 15 to July 24 period was not so favorable as for the other "rust years." During May and June, the days remained moderately cool, and this, together with the absence of hot, drying winds which generally prevail at this time of year, prevented excessive loss of moisture. Heavy dews were frequent during the critical periods.

As mentioned in a former publication [5], stem rust spores require, besides moisture, a minimum temperature not below 55-60° F. for their best development. If we accept 60° F. as the minimum temperature allowing abundant germination and infection to occur, figures 1 to 3 show some points of interest as compared with the epiphytology of stem rust in Kansas in 1935, 1937, and 1938. On April 2 and 3 (fig. 1) there was a short period favorable for infection and records show that moisture was sufficient. It is believed that some infection may have occurred at that time if spores were present in southern Kansas. They could have come from Mexico and Texas where rust was present in abundance at this time. But the minimum temperatures remained too low throughout April to allow stem-rust development in Kansas.

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[4] The total wheat crop for Kansas 1940 according to the Bureau of Agricultural Economics is 123,848,000 bushels.

[5] Plant Disease Reporter Supplement 92. 1936.

The early part of the season (April) was apparently too cool for infection and spread of stem rust in Texas and Oklahoma; otherwise, very heavy losses might have occurred in the Plains area, especially in those regions of Oklahoma and Kansas where the wheat was 10 to 14 days late. It is believed this is the main reason that an epidemic of major importance in Kansas was escaped.

On April 15 and 28 the minimum temperatures approach the point favorable for infection but these short periods are probably of little consequence. Several prolonged, as well as short favorable "infection periods" from May 5 to June 12 are indicated in figure 1. It was during these periods that stem-rust infection and spread undoubtedly occurred and made way for the epidemic that followed.

When the period of May 15 to July 15, 1940 (figs. 1 to 3) is compared with other years, it will be found that favorable, prolonged minimum temperatures extended much further into June and July than ordinarily occurs in Kansas. After July 15, 1940, it is doubtful, however, whether stem rust spread to any extent, even in the late fields, since the maximum temperatures were too high. By that time most of the damage had occurred and the main crop was harvested.

It has been frequently observed and mentioned in the reports on stem-rust epiphytology in Kansas, that the critical period for stem-rust infection and spread in the wheat crop is from about May 15 to June 15 [6]. This is well demonstrated by figures 2 and 3, in which the graphs show favorable infection periods for the period May 15 to June 15, 1935, 1937, 1938 and 1940. In 1940 there were only a few, rather long favorable infection periods which is more like the situation which prevailed during the 1937 epiphytotic, while in 1938, there were numerous very short periods. In 1935 the actual number of days favorable for infection was less than any of the other years mentioned.

The graphs show that the main, favorable infection periods were later in 1940 than in other years and continued into late June and the first two weeks of July. This is significant and helps to explain the outbreak of 1940. Just as important as the favorable environment of 1940 and the presence of spores, is the fact that the wheat crop in southern, central, and parts of eastern Kansas was late and stem rust had ample time to spread and injure the crop. This, of course, does not include the extremely late wheat from seed that germinated after December; most of these fields were a complete failure because of rust and hot weather. As already stated north-central Kansas had wheat free of stem-rust damage. This was also true of eastern Kansas where fields were not late and where Kawvale or Iobred was extensively grown.

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[6] Plant Disease Reporter Supplement 107: 83-94. 1938.

Plant Disease Reporter Supplement 116: 51-68. 1939.

Melchers, L. E. Climate in relation to plant diseases. Trans. Kans. Acad. Sci. (In press).

Isolated areas in eastern Kansas planted to fields of soft wheat of the susceptible varieties were damaged by stem rust; but such acreages were not large. Osage County has the largest loss reported in eastern Kansas.

The Northward Spread of Stem Rust

In 1940, as in 1935, 1937, and 1938, there was every indication that a northward movement of stem-rust spores took place. On May 22, stem rust of wheat was reported by C. O. Johnston at Medford, Oklahoma. From this point south, through central Oklahoma, stem rust increased in prevalence. About this time stem rust was extremely heavy in north-central Texas and in south-central Texas at College Station. Very heavy rains had fallen over this entire area and there was every indication that stem rust would be prevalent and furnish abundant inoculum for the States to the north. Oklahoma had thousands of acres of late wheat which made the situation potentially dangerous. In this connection, it is of interest to examine the reports of the findings in spore traps exposed at Manhattan, Clay Center, and Salina, Kansas (table 1). These places are indicated in figure 4. Of the three stations reported, the heaviest rust spore loads of the air are carried by the wind passing over Clay Center, Kansas. Although no detailed readings for stations in western Kansas are available and only that of Manhattan for the eastern part of the State is given, yet circumstantial evidence leads the writer to believe that probably fewer spores occurred in the air over the eastern and western third of the States for the same dates. It has always been apparent that the heaviest spore loads coming from the southern States enter south-central Kansas and then proceed northward, gradually spreading out in a fan-shaped area as they approach the center of Kansas.

No records were taken of the rust spores in the air around the last of April or up to May 8 (table 1), although such information would be highly desirable each year. Favorable infection periods occurred from May 5 to 8 and if spores were present, infection no doubt did occur. On May 9 readings at Manhattan showed no spores present, yet if readings had been taken at Salina and Clay Center on that date, spores might have been found. It seems certain that spores must have been present in the air in Kansas at this time or earlier, because of the infected wheat reported by several persons and in various areas of southern Kansas on May 26-28. It is believed that wheat in a vast area of Kansas, as well as Oklahoma, may have been infected as early as May 1 to 15 from spores carried by southerly winds. The only readings made at the 3 stations on one date, May 12, however, do not indicate the presence of rust spores, but a reading on May 15 at Manhattan shows 480 spores per square foot per 24 hours. By June 8, stem rust in wheat was found in all fields observed in southern Kansas, and heavy infection was appearing on the stems of the plants in Sumner and Sedgwick Counties, and in areas of Oklahoma south of these Counties. North of Sedgwick County, only primary stem-rust lesions were observed on June 8.

It is of interest to note what the stem-rust conditions were in the Dallas-Sherman, Texas, area at the same time. On June 2 and 3, E. C. Stakman observed that stem rust was exeedingly heavy with 20 percent rust on the necks of the wheat plants. Some fields had 60 percent rust on the stems and were about a week from harvest.

Table 1. -- Stem rust spore counts, Kansas, 1940 [a]

Date	Number of stem rust spores per sq. ft. per 24 hours [b]		
	Salina	Clay Center	Manhattan
May 9			0
12	0	0	0
15	480		
19			480
21		22,560	
23			0
25			480
29		480	
31			0
June 3	13,440	2,580	1,440
4	1,440	9,600	5,280
5	480	3,840	480
6		7,200	
7			960
10		480	480
11			480
13	480		480
14	30,720		10,500
15		33,120	9,500
16		480	
17		1,440	4,800
18		71,520	26,880
19		104,640	12,240
20		49,920	
21		31,680	
24		76,800	
25		18,240	

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[a] These counts were made by Max C. Markley, Cargill, Inc., Minneapolis, Minnesota.

[b] Microscopic slides, coated with an adhesive, are exposed to the air in a prescribed manner and location. Each exposure is for a 24-hour period.

The importance of this area and other fields in northern Texas to the States to the north lay in the vast supply of inoculum they furnished. The rust was in the uredial stage in Texas on June 2 and 3 and some fields were so heavily rusted as to appear distinctly discolored when observed from a distance. On June 2 and 3 moderate to strong winds were blowing from the south, which, no doubt, were carrying rust spores into Oklahoma and Kansas. On those dates a note on weather conditions at Manhattan shows: June 2, "Warm, bright day following heavy dew and high humidity. Strong southerly winds blew all day." June 3, "Strong southerly winds all day. Slight dew, hot, relative humidity 50%." The spore trap readings for June 3 to 6 are extremely interesting in that the numbers are very high, showing conclusively that the winds were loaded with stem rust spores. The minimum temperatures for these dates were favorable, moisture was sufficient for infection as 1.5 inches of rain occurred on June 7. This unquestionably precipitated a large amount of inoculum on the Kansas wheat. On June 14 the heaviest spore loads of the season were being reported from all 3 Kansas stations and the readings taken from June 14 to June 25 show a uniformly heavy spore load in the air. From June 14 to about June 30, temperature and moisture were very favorable and stem rust was spreading rapidly over central and parts of eastern Kansas. The amount of infection that occurred in June gave a substantial start which spread into the late wheat maturing in the first 2 weeks of July.

Several other points of interest with respect to the stem-rust epiphytotic in 1940 and the development of the wheat crop should be mentioned. As already stated, much of the crop was 10 to 14 days later than normal. This does not consider the large acreage in which the seed did not germinate until December or later and in which the wheat heads were in flower about June 15 to 20. The lateness of all this wheat made conditions ideal for the stem rust epiphytotic. The wheat crop in the north-central counties was 2 weeks in advance of the crop in the southern part of the State, a very unusual situation. The crop was ripening about June 15 in the north-central area and was harvested soon thereafter. No stem-rust damage occurred in that area; in fact, little stem rust was present. But on this same date stem rust was severe in central and southern Kansas.

Route Followed in Stem-rust Survey, 1940

Mr. John O. Miller, extension plant pathologist, and the writer made a trip through central Kansas where stem rust was most likely to become severe and where the crop was late. This route is shown in figure 4, the trip being made on June 12-14. Other areas of the State were visited on earlier and later dates by college officials, but these places are not indicated on the map. Mr. John O. Miller and the author examined hundreds of fields, and notes were taken on the amount and location of stem rust on plants, the condition of the field, days remaining before harvest, and estimated damage. In August letters were written to County Agents, who in turn questioned millers and farmers in their counties in order to obtain a cross-section opinion for their county as to how much loss occurred. The figures in figure 4 represent the estimates of loss expressed in the several counties. Those counties (fig. 4) which reported losses, represent the area which produced 63 percent of the entire wheat crop of Kansas in 1940.

Magnitude and Types of Losses in 1940

Losses varied considerably according to locality and crop conditions and it is difficult to reach a single figure on the loss for the State. An estimate of an average loss of 7 percent for the State has been made and is believed to be fairly accurate. The heaviest loss occurred in those counties in the southern part of central Kansas indicated in figure 4. This area had considerable wheat that was very late and succulent when stem rust was most severe. Some of this wheat was not harvested and other fields produced light-weight grain of little value. The loss in this area was solely that resulting from stem rust and not heat injury. Lyon, Franklin, and Osage Counties in the central part of eastern Kansas had considerable injury. Other than these 2 areas, the infection was only moderate, light, or trace as indicated in figure 4, the numbers indicating percent loss.

As in other recent epiphytotics, the loss from stem rust consisted of actual reduction in yield, reduced grade due to shrivelling, and abandoned fields. No figures are available for the latter, but it is known that most fields of very late wheat were a total loss.

Leaf rust of wheat _Puccinia_ _triticina_, [_P_. _rubigo-vera_ _tritici_] was not a factor in the 1940 wheat crop and no appreciable loss could be assigned to it. In fact none of the other diseases, such as black chaff, basal glume blotch, Septoria glume blotch, or _Septoria_ _nodorum_ on the nodes, foot and root rots, etc., that complicated the estimated losses from stem rust in 1938, was present in sufficient amounts in 1940 to make the matter of estimates on stem-rust loss confusing. On a basis of 7 percent loss, the reduction in yield from stem rust in Kansas was about 9,321,892 bushels.

Varietal Susceptibility to Stem Rust

Kansas does not have a good commercial hard winter wheat that is resistant to stem rust. Kanred, Turkey, and Tenmarq were heavily attacked in some fields although Kanred does show a little more resistance than the other 2 varieties. Among the other hard wheats, Early Blackhull and Blackhull had very little stem rust. Kawvale and Iobred in eastern Kansas were definitely outstanding in their field resistance and showed no appreciable damage. Wherever fields of Fulcaster, Harvest Queen, and Michigan Wonder were encountered, the plants were heavily rusted. Although Iobred, Kawvale, Early Blackhull, Blackhull, and Kanred are recognized as possessing some resistance to stem rust, none has the degree of resistance necessary to protect the Kansas wheat crop from severe losses when stem rust becomes severe. For this reason, increased efforts have been and are being devoted to the matter of obtaining hybrids that are resistant to stem rust and that possess all other agronomic qualities necessary in this region. Promising hybrids in the F_3 to F_8 generations are being subjected to annual artificial epiphytotics of stem and leaf rust in the Botany rust nursery. It is hoped that before long Kansas will be growing a satisfactory rust-resistant, hard winter wheat.

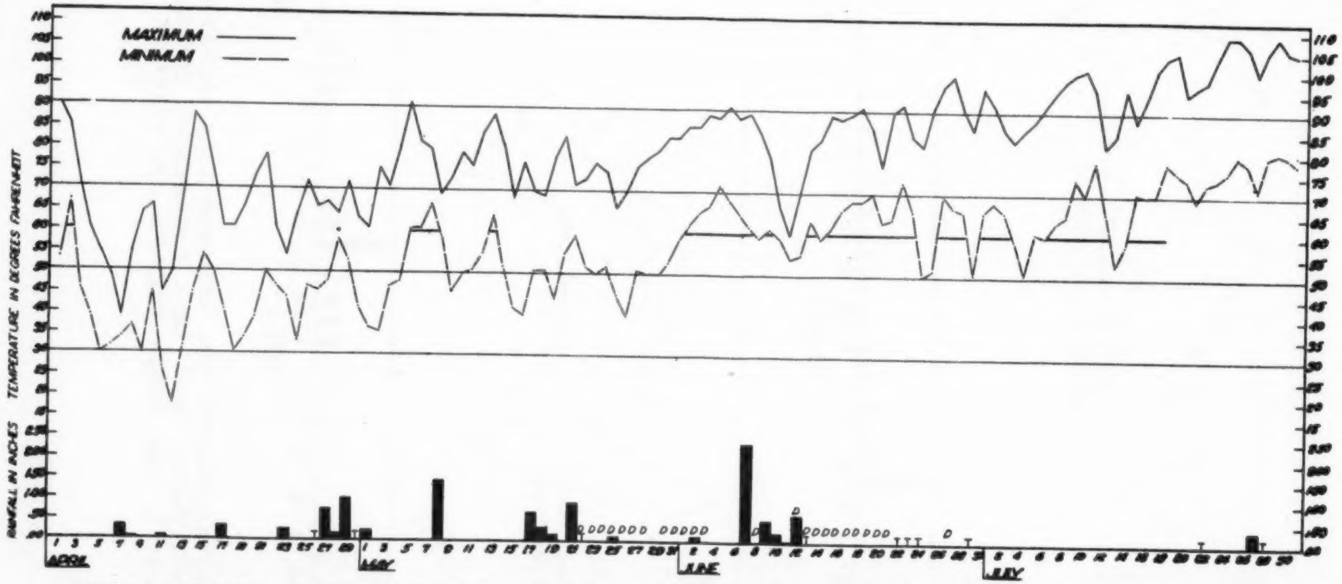


FIG. I

MAXIMUM AND MINIMUM AIR TEMPERATURES, RAINFALL AND PERIODS FAVORABLE FOR THE DEVELOPMENT OF STEM RUST AT MANHATTAN, KANSAS FROM APRIL 1st TO JULY 30, 1940

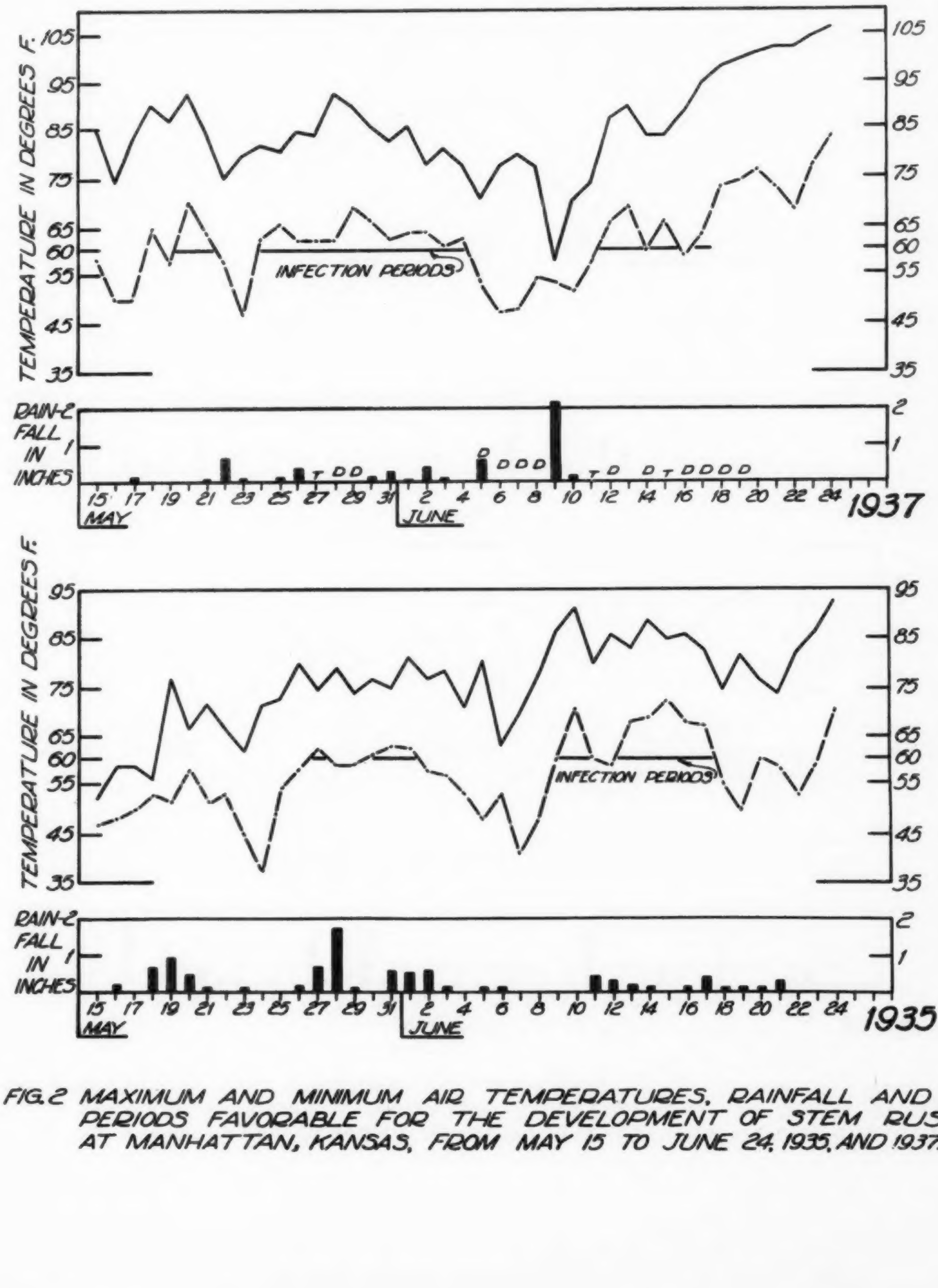


FIG. 2 MAXIMUM AND MINIMUM AIR TEMPERATURES, RAINFALL AND PERIODS FAVORABLE FOR THE DEVELOPMENT OF STEM RUST AT MANHATTAN, KANSAS, FROM MAY 15 TO JUNE 24, 1935, AND 1937.

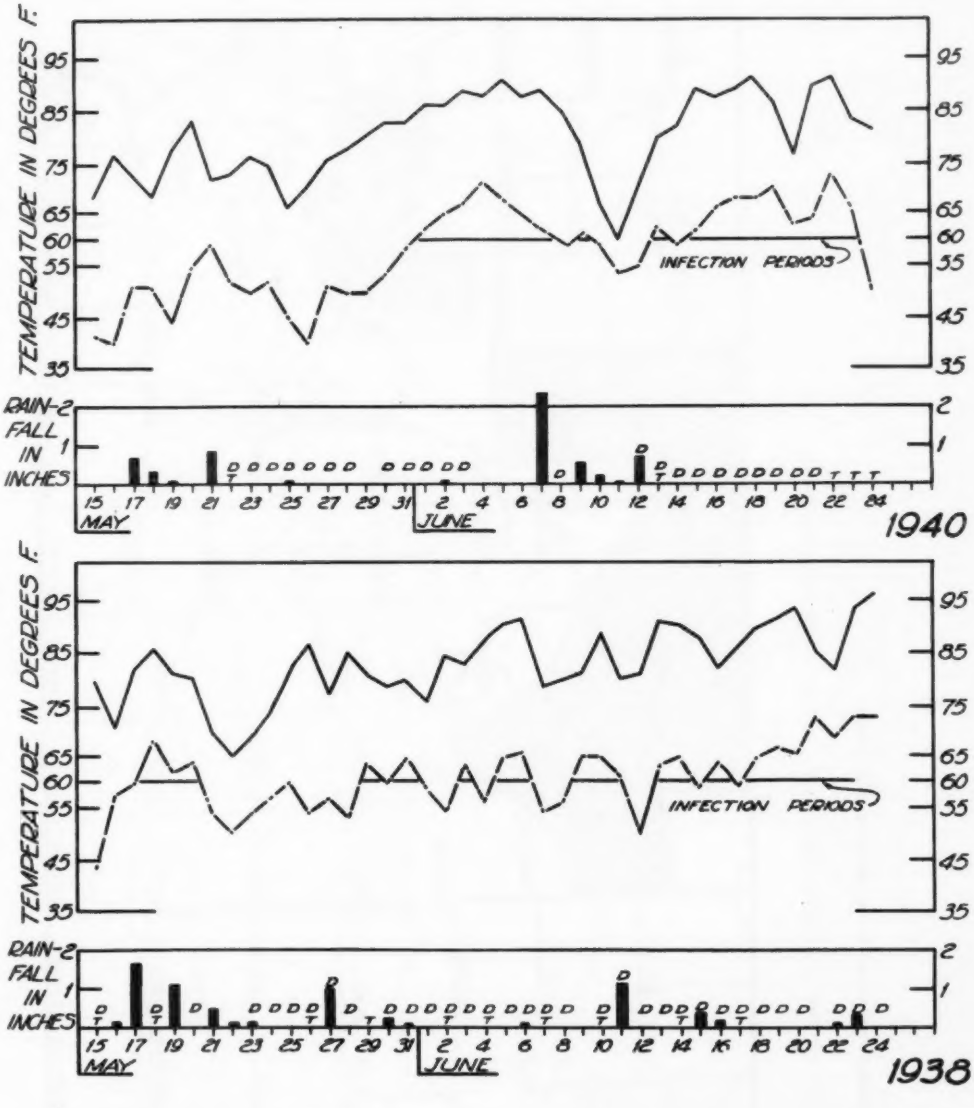
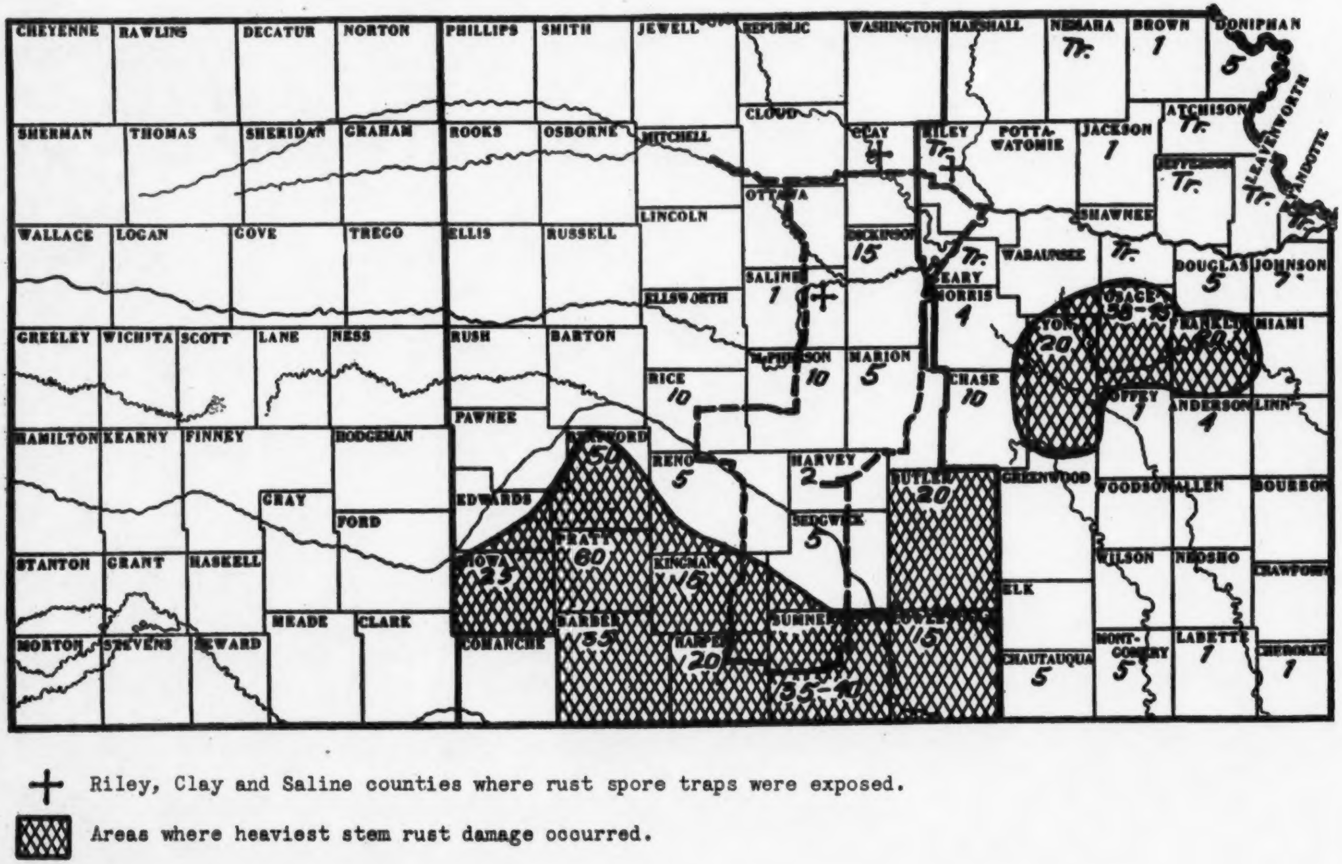


FIG. 3 MAXIMUM AND MINIMUM AIR TEMPERATURES, RAINFALL AND PERIODS FAVORABLE FOR THE DEVELOPMENT OF STEM RUST AT MANHATTAN, KANSAS, FROM MAY 15 TO JUNE 24, 1938, AND 1940.

Kansas Stem Rust Epiphytotic, 1940


CHEYENNE
RAWLINS
DECATUR
NORTON
PHILLIPS
SMITH
JEWELL
REPUBLIC
WASHINGTON
MARSHALL
NEMAHA Tr.
BROWN 1
DONIPHAN 5
SHERMAN
THOMAS
SHERIDAN
GRAHAM
ROOKS
OSBORNE
MITCHELL
CLOUD
CLAY
RILEY Tr.
POTTA-WATOMIE
JACKSON 1
ATCHISON Tr.
JEFFERSON Tr.
LEAVENWORTH Tr.
WYANDOTTE Tr.
WALLACE
LOGAN
GOVE
TREGO
ELLIS
RUSSELL
LINCOLN
OTTAWA
DICKINSON 15
GEARY Tr.
WABAUNSEE
SHAWNEE Tr.
DOUGLAS 5
JOHNSON 7
ELLSWORTH
SALINE 1
MORRIS 4
OSAGE 30-35
LYON 20
FRANKLIN 20
MIAMI
GREELEY
WICHITA
SCOTT
LANE
NESS
RUSH
BARTON
RICE 10
McPHERSON 10
MARION 5
CHASE 10
COFFEY 1
ANDERSON 4
LINN
HAMILTON
KEARNY
FINNEY
HODGEMAN
PAWNEE
STAFFORD 50
RENO 5
HARVEY 2
BUTLER 20
GREENWOOD
WOODSON
ALLEN
BOURBON
GRAY
FORD
EDWARDS
SEDGWICK 5
STANTON
GRANT
HASKELL
KIOWA 25
PRATT 60
KINGMAN 15
ELK
WILSON
NEOSHO
CRAWFORD
MORTON
STEVENS
SEWARD
MEADE
CLARK
COMANCHE
BARBER 55
HARPER 20
SUMNER 35-40
COWLEY 15
CHAUTAUQUA 5
MONT-GOMERY 5
LABETTE 1
CHEROKEE 1

+ Riley, Clay and Saline counties where rust spore traps were exposed.

▨ Areas where heaviest stem rust damage occurred.

Fig. 4.